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(54) Title: EL DEVICE WITH ENHANCED CONTRAST

(57) Abstract: An EL device with enhanced contrast in a flat panel display is provided. One embodiment includes a electroluminescent display having a front electrode, an electroluminescent layer, an optical interference member, and reflective rear electrode. The optical interference member is made from a semi-absorbing material, and the actual material, its thickness, "n" value, and "k" value are all so chosen such that ambient light incident upon the display is substantially reduced by destructive interference.

EL DEVICE WITH ENHANCED CONTRAST

The present application claims priority from Canadian Patent Application Serial Number 2,352,390 filed 4 July 2001, the entirety of which is incorporated herein by reference. The teachings of U.S. Patent 5,049,780 issued to Dobrowolski et al., and of applicant's WIPO publication WO01/08240 published 1 February 2001 in the names of Hofstra et al, as discussed hereafter, are also incorporated herein by reference in their entireties.

The present invention relates generally to display devices and more specifically relates to flat display devices having high contrast.

Thin display devices are well-known and are expected to achieve wide acceptance in commercial applications that utilize displays, such as computer monitors, televisions, cell phones, personal digital assistants and the like. Thin film electroluminescent devices (ELDs) are generally constructed of several layers of different materials. A simple ELD consists of a transparent front-electrode layer, an electroluminescent layer and a rear-electrode layer. When electricity is applied across the electrodes, the electroluminescent layer becomes active, converting some portion of the electrical energy passing therethrough into light. This light is then emitted out through the front-electrode where it is visible to a user of the device.

It is also known to construct ELDs from inorganic or organic materials. Inorganic devices are typically voltage driven, and typically utilize additional dielectrics to reduce electrical-breakdown of the inorganic electroluminescent layer. More modern organic ELDs are typically current driven and require careful matching of work-functions of each layer in order to ensure proper operation of the device. However, organic ELDs are currently favoured over inorganic ELDs for certain applications because of, for example, higher colour capability and reduced barriers to current flow thereby reducing the necessary drive voltage.

Whatever the underlying display technology, it is generally desirable to add a contrast enhancement apparatus to ELDs to further improve their display characteristics. In particular, in any environment where ELDs are exposed to

incident ambient light, it is usually desired to add contrast enhancing features to allow the user to more readily read the display and avoid the distractions of glare and reduced contrast resulting from the ambient light incident on the display.

Several types of contrast enhancing apparatuses are known. Polarizing filters and purely absorbing filters are two common contrast enhancing apparatuses. Both of these contrast enhancing technologies suffer from the disadvantage that, in addition to reducing ambient light incident on the display, they also tend to reduce some of the light actually emitted from the display, thereby requiring more energy to drive the display in order to compensate for the emitted light reduced by the contrast enhancing apparatus.

It is the belief of the inventors of the present invention, however, that a superior contrast enhancement apparatus is achieved by using additional thin film layers sandwiched between one or more layers of the ELD, which are configured to achieve destructive optical interference of the ambient light incident on the display, thereby substantially reducing incident ambient light. Optical interference contrast enhancement apparatuses are discussed in detail in U.S. Patent 5,049,780 to Dobrowolski et al., and the applicant's WIPO publication WO01/08240 published 1 February 2001, in the names of Hofstra et al. In addition to enhancing contrast, the optical interference contrast enhancement apparatuses discussed in Dobrowolski and Hofstra also reduce pixel blooming and solar loading – another advantage of such apparatuses over certain other types of contrast enhancement apparatuses.

While Dobrowolski et al and Hofstra et al both generally contemplate the use of an optical interference member as a contrast enhancement apparatus, more specific teachings therein contemplate an optical interference member that is comprised of at least a substantially transparent layer that has a thickness and material such that the spectral reflectance of the overall ELD is so modified that the reflectance of ambient light towards a viewer is reduced. This prior art single layer contrast enhancement apparatus can be desirable where the substantially transparent layer is located, in relation to the viewer, in front of the

electroluminescent layer. However, Dobrowolski et al and Hofstra et al further teach the use of an optical interference member that comprises both a substantially transparent layer and a semi-absorbing layer. Those inventors determined that, the latter, two layer, optical interference member (i.e. an optical interference member that comprises both a substantially transparent layer and a semi-absorbing layer) can be desired, in certain configurations, to the single layer optical interference member that only includes a single substantially transparent member. For example, the two layer optical interference member can offer improved contrast enhancement over the prior art single layer optical interference member where the two layer optical interference member is located, in relation to the viewer, behind the electroluminescent member.

While such two layer optical interference members provide impressive contrast enhancement to ELDs, it can be somewhat more costly and/or more time consuming to manufacture two layer optical interference members than single layer optical interference members. Furthermore, as previously mentioned, certain prior art single layer configurations do not always achieve the desired contrast enhancement. Accordingly, it is desired to provide an optical interference contrast enhancement apparatus with a reduced number of layers and/or that can offer certain advantages over prior art single layer optical interference contrast enhancement apparatuses.

The present invention can also reduce pixel blooming and reduce solar loading.

Thus, the present invention provides a device for displaying an image to a viewer in front of the device, comprising: a front electrode that is substantially transparent to electroluminescent light; a rear electrode that is reflective to ambient light; and a light emitting means disposed between the electrodes that emits light when an electrical circuit is formed between the electrodes.

The device is particularly characterized by further comprising an optical interference member which is composed of a single layer of a semi-absorbing material. The optical interference member is in interfacial contact with the rear

electrode, and is disposed between the rear electrode and the light emitting means. The purpose of the optical interference member is for reducing the reflectance of the ambient light towards the viewer.

In any device in keeping with the present invention, the light emitting means is one of a plasma or a plasma induced phosphor emitter.

However, more typically, the light emitting means is an electroluminescent layer.

If so, then one embodiment of device in keeping with the present invention employs an electroluminescent layer which is made from an organic material. In that case, the optical interference member is work function matched therewith.

Still further, the electroluminescent layer may be made from an organic material. In that case, the device further includes a work function matching layer between the optical interference member and the organic material, and in interfacial contact therewith.

In the latter case, the work function matching layer is made from one of LiF and LiO.

In other embodiments of devices in keeping with the present invention, the electroluminescent layer may be made from an inorganic material.

Still further, other devices in keeping with the teachings hereof may comprise an electroluminescent layer which is is made from an inorganic material, together with at least one further dielectric layer.

In any device in keeping with the above descriptions, the semi-absorbing material has a "k" value of less than about 0.2 and greater than 0.1, an "n" value of from about 1.3 to about 3.5, and a thickness optimized to reduce optical interference at a wavelength of visible light of about λ=555nm.

Other embodiments of the present invention provide a contrast enhancement apparatus which comprises a reflective rear layer. In these embodiments, the the contrast enhancement apparatus is characterized by further comprising an optical interference member which is composed of a single layer of a semi-absorbing material. Once again, the optical interference member is in

interfacial contact with the reflective rear layer; and once again, the purpose of the optical interference member is for reducing the reflectance of the ambient light towards a viewer facing the optical interference member.

In such apparatus as described immediately above, the semi-absorbing material is a metal rich oxide chosen from the group consisting of AlO, SiO, InO, and ZnO.

Alternatively, the semi-absorbing material is a metal:metal oxide chosen from the group consisting of Cr:SiO, Al:SiO, In:SnO, and Al:ZnO.

Still further, the semi-absorbing material may be a metal:metal halide chosen from the group consisting of Al:LiF, Ag:MgF, and AgLiF.

Alternatively still, the semi-absorbing material may be a metal:organic thin-film material chosen from the group consisting of Al:Alq_3, Cr:Alq_3, Mg:Alq_3, and Li:Alq_3.

Another aspect of the present invention provides an electroluminescent device for displaying an image to a viewer in front of the device, which comprises an anode layer, and a cathode layer. Here, the electroluminescent device is characterized by the fact that at least one of the anode layer and the cathode layer is a front layer, and is substantially transparent to electroluminescent light. Moreover, the electroluminescent device further comprises an electroluminescent layer which is disposed between the cathode layer and the anode layer.

Here. the electroluminescent layer has a highest occupied molecular orbital associated with the anode side, and a lowest unoccupied molecular orbital associated with the cathode side.

This embodiment of electroluminescent device in keeping with the present invention also further comprises an optical interference member whose purpose is for reducing the reflectance of ambient light towards the viewer. The optical interference member is disposed between the anode layer and the cathode layer; and the optical interference member has a work function which is such that a first difference between the work function and a first energy level that is required to remove an electron from the highest occupied molecular orbital, when the optical

interference member is at the anode side, approaches zero; and a second difference between the work function and a second energy level that is required to remove an electron from the lowest unoccupied molecular orbital, when the optical interference member is at the cathode side, approaches zero;

The optical interference member is composed of a single layer of a semi-absorbing material.

The present invention also provides a method of displaying an image to a viewer, which method is characterized by the following steps:

First, light is emitted from a light emitting means which is sandwiched between a substantially transparent front electrode and a reflective rear electrode.

Then, spectral reflectance from ambient light incident upon the light emitting means is reduced with an optical interference member disposed in interfacial contact with the rear electrode. As before, the optical interference member is composed from a single layer of a semi-absorbing material.

Finally, a further method of reducing reflected ambient light towards a viewer, in keeping with yet another aspect of the present invention is characterized by the following steps:

A first portion (R1) of ambient light (L_{amb}) incident upon a semi-absorbing material is reflected back.

A second portion ($L_{amb}1$) of the ambient light is absorbed as it passes through the semi-absorbing material.

Then, a third portion (R2) of the ambient light is reflected after it passes through the semi-absorbing material and when the third portion is incident upon a reflecting material which is in interfacial contact with the semi-absorbing material.

A fourth portion of the ambient light is absorbed from the third portion as the third portion passes back through the semi-absorbing material.

Finally, the remainder of the ambient light is transmitted out of the reflecting portion. However, the remainder of the ambient light is out of phase with the first portion such that the first portion and the remainder destructively

interfere with each other, thereby reducing the ambient light reflected back towards the viewer.

The present invention will now be described, by way of example only, with reference to certain embodiments shown in the attached Figures in which:

Figure 1 is a schematic representation of a cross-section of through a portion of a display device in accordance with an embodiment of the invention;

Figure 2 is a partial view of the display device of Figure 1, which only shows the optical interference member and rear electrode;

Figure 3 is a schematic representation of a cross-section of through a portion of an organic electroluminescent display device in accordance with another embodiment of the invention; and,

Figure 4 is a schematic representation of a cross-section of through a portion of an inorganic electroluminescent display device in accordance with another embodiment of the invention.

Referring to Figure 1, an electroluminescent device incorporating a contrast enhancement apparatus that is in accordance with a first embodiment of the invention is indicated generally at 20. Device 20 comprises a front electrode 24 that is substantially transparent to light. Device 20 further comprises an electroluminescent layer 28 disposed behind front electrode 24, an optical interference member 32 disposed behind the electroluminescent layer 28 and a reflective rear electrode 36. Thus, a viewer 40 in front of device 20 will view electroluminescent light emitted L_{em} from electroluminescent layer 28 as it passes through front electrode 24. Additionally, device 20 is subject to ambient light L_{amb} which is incident on display 20. Furthermore, a certain amount of ambient light L_{amb} will reflect off the device 20 and appear as reflected light L_{ref} to viewer 40. As will be discussed in greater detail below, however, the intensity of reflected light L_{ref} is substantially reduced in relation to the amount of ambient light L_{amb} due to the effects of optical interference member 32.

The components in device 20, other than optical interference member 32, can be constructed with known components to fit with known configurations of

inorganic or organic electroluminescent displays, although such known configurations shall be suitably modified to accommodate optical interference member 32, as will become more apparent from the following discussion. Examples of inorganic or organic electroluminescent display configurations are available from a variety of sources, and can be found in, for example, the teachings of Dobrowolski et al or Hofstra et al, referred to above. It should also be apparent to those of skill in the art, electrodes 24 and 36 can be connected to, for example, a voltage source for an inorganic device or a current source for an organic device. When device 20 is an organic device it will be understood that typically the front electrode 24 is the anode, while the reflective rear electrode 36 is typically the cathode. In an inverse device, then typically the front electrode 24 is the cathode, while the reflective rear electrode 36 is typically the anode.

More specifically, transmitting front electrode 24 can be constructed from any conducting material that is transparent to at least a portion of emitted electroluminescent light, and chosen in thickness and conductive materials to suit the organic or inorganic nature of device 20. For example, indium tin oxide (ITO) or zinc oxide (ZnO) can be employed. Additionally, electroluminescent layer 28 is made from any electroluminescent material that emits electroluminescent light when an appropriate electrical circuit is made between electrodes 24 and 36, and is thus made according to any desired configuration and thickness that conforms with known techniques for making electroluminescent layers.

For example, where device 20 is an organic device, then a polymer based or small molecule based organic electroluminescent material can be used. Examples of such organic electroluminescent material include tris(8-hydroxyquinoline aluminum) (Alq3) or poly(p-phenylene vinylene) (PPV). In particular, when device 20 is an organic device, those of skill in the art will recognize the need for "work function matching" of each of the layers, due to the unique electrical properties of organic electroluminescent materials. Such work function matching can be done on a layer-by-layer basis, carefully choosing thicknesses and materials that match, or, a work function matching layer (not

shown in Figure 1) can be added. One suitable work function matching layer can be Lithium Fluoride (LiF), and if included, would be located between layers 32 and layer 28. Yet another suitable type of work function matching layer can be Lithium Oxide (LiO). A discussion of the use of LiF in organic display devices can be found in, Hung L.S., Tang C.W. and Mason M.G., "Enhanced electron injection in organic electroluminescence devices using an Al/LiF electrode", Applied Physics Letters 70(2), 13 January 1997, p.152.

In contrast, where device 20 is an inorganic device, then a suitable electroluminescent material for layer 28 is zinc-sulfide doped with manganese (ZnS:Mn). While not required (or shown in Figure 1), if device 20 is an inorganic device then it is typically preferred to include a dielectric layer between front electrode 24 and electroluminescent layer 28, and another dielectric layer between optical interference member 32 and electroluminescent layer 28. Other configurations for electroluminescent layer 28 will occur to those of skill in the art.

The contrast enhancement of device 20 is achieved through a cooperation of optical phenomena between optical interference member 32 and rear electrode 36. More particularly, optical interference member 32 is a thin film layer made from a semi-absorbing material.

Subject to the electrical properties of device 20 (which, as previously discussed, can vary depending on whether it is organic, or inorganic, and/or vary according to the which specific materials and thicknesses are used for each of the other layers in device 20), semi-absorbing materials suitable for use in the present invention are metal oxides, such as AlO, SiO, InO, SnO, ZnO. (In the case of the foregoing metal oxides, it will be understood by those of skill in the art that a metal rich oxide is used to achieve semi-absorbency.) It is also believed that metal:metal oxide materials can be suitable for the present invention, such as Cr:SiO, Al:SiO, In:SnO or Al:ZnO. Further, various solid film mixtures can be used such as Al:LiF, Ag:LiF, Ag:MgF. It is also contemplated that semi-absorbing materials can be used such as an absorbing material such as a metal

(e.g. Al, Cr, Mg, Li) mixed with Alq_3 or other organic compounds that are operable to carry an electrical charge or as can be used in organic electroluminescent display devices. Other types of semi-absorbing/conducting materials suitable as a semi-absorbing material for optical interference member 32 may occur to those of skill in the art.

Thus, when device 20 is an organic display, the semi-absorbing material for member 32 is conducting and is "work function matched" to surrounding organic layers, such as to an organic electroluminescent layer 28. Alternatively, where device 20 is an organic display, then a "work function matching" layer, such as LiF or LiO, will be added between member 32 and electroluminescent layer 28.

In contrast, when device 20 is an inorganic display, it is generally preferred to use, (in addition to the other layers shown in device 20), insulating films that will behave as a dielectric within the entire electrical circuit between front electrode 24 and the rear electrode 36.

Regardless of the material chosen from within the above-mentioned scope of semi-absorbing materials for member 32, it is believed that member 32 can have a thickness of from about three-hundred nanometers ("nm") to about five nm. It is further believed that it can be more preferable, however, that member 32 have a thickness of from about two-hundred nm to about twenty nm. It is further believed, however, that member 32 can have a thickness of from about one-hundred nm to about fifty nm.

However, in addition to material and thickness considerations, the optical properties of the semi-absorbing material for optical interference member 32 can be described in terms of its index of refraction:

i. real index of refraction, also referred to as its "n" value; and,

ii. imaginary index of refraction, also referred to as its "k" value.

Additionally, the thin film layer of semi-absorbing material can be described in terms of its thickness.

It is believed that the semi-absorbing material can have an "n" value of from about 1.3 to about 3.5. It is further believed that it can be more preferable,

however, that member 32 have an "n" value of from about 1.6 to about 2.3. It is further believed, however, that member 32 can have an "n" value of of from about 1.9 to about 2.0.

It is presently preferred that the "k" value of the semi-absorbing material be less than about 2 but greater than 0.1. It is further believed that it can be more preferable that member 32 has a "k" value less than about 1.0, but greater than about 0.4. It is further believed, however, that member 32 can have an "k" value of less than about 0.2, but greater than 0.1.

As mentioned previously, the contrast enhancement of device 20 is achieved through a cooperation of optical phenomena between optical interference member 32 and rear electrode 36, which is reflective. Thus, rear electrode 36 is primarily chosen in order to accommodate the electrical requirements to operate device 20, and is typically expected to some sort of reflective metal, such as Al, Ag, Mg/Ag, Au, Ni, NiCr. It is to be understood, however, that any reflective metal suitable as rear electrode 36 for device 20, in relation to viewer 40, can be used and is within the scope of the invention.

The operation of the optical features of device 20 will now be discussed with reference to Figure 2, which is a partial view of device 20 that only shows optical interference member 32 and rear electrode 36. Figure 2 only shows ambient light L_{amb} after it has passed through front electrode 24 and electroluminescent layer 28, and in particular as ambient light L_{amb} is incident upon optical interference member 32. A portion of ambient light L_{amb} that is incident upon optical interference member 32 is immediately reflected back towards viewer 40 from the surface of member 32 that is closest to viewer 40, this reflection being represented in Figure 2 as reflection R1. The portion of ambient light L_{amb} that is not reflected as reflection R1 continues to travel through optical interference member 32, where, due to the absorbing properties of the semi-absorbing material used to construct optical interference member 32, a portion is absorbed and dissipated as heat. This portion that continues through member 32 and experiences a small amount of absorption is represented on Figure 2 as

ambient light $L_{amb}1$. The portion of ambient light $L_{amb}1$ that is not absorbed hits the surface of rear electrode 36, where it is reflected back though optical interference member 32. This reflection is indicated on Figure 2 as reflection R2. As reflection R2 passes back through optical interference member 32, some portion of reflection R2 is also absorbed by optical interference member 32. However a remaining portion of R2 exits from the surface of member 32 that is closer to viewer 40. At this point, reflection R2 is now inverted and one-hundred-and-eighty degrees out of phase from reflection R1. Thus, when the resulting reflections R1 and R2 interact at the surface of member 32 that is closest to viewer 40, they will be one-hundred-and-eighty degrees out of phase from each other, and will therefore destructively interfere with each other, thus resulting in a reduction of the overall reflected light L_{ref} from device 20.

The person of skill in the art should now appreciate that the above-mentioned ranges for material selection, thicknesses and optical properties of member 32 and electrode 36 are intended to be illustrative of suitable ranges that will offer varying results in the reduction of reflected light L_{ref} when combined. In general, the materials, thicknesses and optical properties of the member 32 and electrode 36 are chosen to achieve a desired amount (typically the greatest amount) of destructive interference of reflections R1 and R2 in order to reduce reflected light L_{ref} back towards viewer 40.

Referring now to Figure 3, an example of an organic electroluminescent device is indicated generally at 20a, in accordance with another embodiment of the invention. Items in device 20a of Figure 3 that are related to parts in device 20 in Figure 1 are indicated with the same reference numeral, but followed by the suffix "a". Thus, Table I illustrates the various layers, their thicknesses, and optical properties of the items in Figure 3.

Table I

Reference Number	Item Name	Thickness	Material	"k" value	"n" value
24a	Front electrode (Anode)	1500 Å	Indium Tin Oxide	0	1.52
26a	Hole Transport Layer	1700 Å	TPD (triphenyl diamine derivative)	0	1.75
28a	Electroluminescent layer	500 Å	Alq3	0	1.7
30a	Work Function Matching Layer	5 Å	LiF	0	1.4
32a	Optical Interference Member	1040 Å	AlLiF	0.5	1.8
36a	Rear electrode (Cathode)	2000 Å	Al	7.5	1.4

In operation, device 20a operates in substantially the same manner as device 20, as previously described. It is believed when device 20a is configured as described in Table I, then the reflected light L_{ref} towards viewer 40 will be, on average, about 2.05% of ambient light L_{amb} incident on device 20a.

Referring now to Figure 4, an example of an inorganic electroluminescent device is indicated generally at 20b, in accordance with another embodiment of the invention. Items in device 20b of Figure 4 that can be related to parts in device 20 in Figure 1 are indicated with the same reference numeral, but followed by the suffix "b". Thus, Table II illustrates the various layers, their thicknesses, and optical properties of the items in Figure 4.

Table II

Reference Number	Item Name	Thickness	Material	"k" value	"n" value
24b	Front electrode	1500 Å	Indium Tin Oxide	0	1.85
27b	Dielectric layer	800 Å	Al_2O_3	0	1.65
28b	Electroluminescent layer	5000 Å	ZnS	0	2.32
29b	Dielectric layer	1500 Å	Al_2O_3	0	1.65

32b	Optical Interference Member	2200 Å	CrSiO	0.3	2.1
36b	Rear electrode	2000 Å	Al	7.5	1.4

In operation, device 20b operates in substantially the same manner as device 20, as previously described. It is believed when device 20b is configured as described in Table II, then the reflected light L_{ref} towards viewer 40 will be, on average, about 7.3 percent of ambient light L_{amb} incident on device 20b.

Device 20, device 20a, and device 20b can all be manufactured using known techniques, such as by vacuum deposition, using, for example, thermal evaporation, electron beam evaporation, sputter deposition, either individually or concurrently. Each layer, beginning with the front electrode, can be, for example, successively layered upon a glass substrate having a thickness of about 1.1 mm, and then the entire package can be sealed using known sealing techniques. Other film processing techniques can also be used to manufacture device 20, device 20 and device 20b, such as spin coating and ink jet printing and as appropriate to the type of materials being deposited

While only specific combinations of the various features and components of the present invention have been discussed herein, it will be apparent to those of skill in the art that desired subsets of the disclosed features and components and/or alternative combinations of these features and components can be utilized, as desired. For example, the embodiments discussed herein refer to a contrast enhancement apparatus that is electrically incorporated into the display device. However, in other embodiments, the optical interference member can be simply mounted to a reflective material, in the substantially the same manner that optical interference member 32 and rear electrode 36 are assembled – yet no considerations of the electrical operation of the device need be considered. In this particular variation, the semi-absorbing optical interference member 32 and

reflective material combination can be mounted, for example, behind a device that has both a transparent front electrode and transparent rear electrode.

Furthermore, it is to be appreciated that the embodiments discussed herein are optimized for reduced reflection of ambient light L_{amb} at a wavelength where λ=555nm, and that such selection can provide good results over the range of wavelengths ambient light L_{amb} that are perceptible to the human eye. The discussions of materials, thicknesses, and optical properties are made according to this optimization of λ=555nm, approximately the centre of the visible spectrum to the human eye. Further, the average reflectances discussed herein are directed to the perceptions of the human eye, also known as photopic reflectance. It should be understood that other optimizations can be chosen, however, and such optimizations are within the scope of the invention.

The present invention can be suitable for patterned displays, such as pixellated, using pattern forming techniques that are known to those of skill in the art. The present invention can also be used in active matrix displays.

Another variation of the present invention is where electroluminescent layer 28 is substituted for another type of light emitting means that emits light when an electrical circuit is formed between electrode 24 and electrode 26. For example, in a plasma display, a plasma layer could be substituted for electroluminescent layer 28 to produce either plasma light emission or plasma induced phosphor light emission, depending on the type of plasma device used

The present invention provides a novel organic electroluminescent device having a single layer optical interference member made of a semi-absorbing material, that cooperates with a reflective surface, such as a rear electrode, to reduce the overall reflectance from the device. The optical interference member is selected to have a thickness, a "k" value, and an "n" value which causes at least some destructive optical interference of ambient light incident on the display. The use of a single layer to produce optical interference can reduce the complexity of manufacture, while still providing a display device with good contrast enhancement. Furthermore, the present invention can offer certain advantages

over contrast enhancement apparatuses that purely rely on absorption as a means of reducing reflected ambient light, such prior art devices typically requiring thicker layers of absorbing or semi-absorbing material that do not necessarily achieve as great a reduction in spectral reflectance as can be provided by the present invention.

CLAIMS:

1. A device (20, 20a, 20b) for displaying an image to a viewer (40) in front of said device, said device comprising:

a front electrode (24, 24a, 24b) that is substantially transparent to electroluminescent light;

a rear electrode (36, 36a, 36b) that is reflective to ambient light; and

a light emitting means (28, 28a, 28b) disposed between said electrodes that emits light when an electrical circuit is formed between said electrodes;

wherein said device is **c h a r a c t e r i z e d** by further comprising:

an optical interference member (32, 32a, 32b) composed of a single layer of a semi-absorbing material, said optical interference member being in interfacial contact with said rear electrode and disposed between said rear electrode and said light emitting means, said optical interference member for reducing the reflectance of said ambient light towards said viewer.

2. The device according to claim 1, wherein said light emitting means is one of a plasma or a plasma induced phosphor emitter.

3.. The device according to claim 1, wherein said light emitting means is an electroluminescent layer.

4. The device according to claim 3, wherein said electroluminescent layer (28a) is made from an organic material and said optical interference member is work function matched therewith.

5. The device according to claim 3, wherein said electroluminescent layer (28a) is made from an organic material and said device further includes a work function matching layer (30a) between said optical interference member and in interfacial contact with said organic material.

6. The device according to claim 5, wherein said work function matching layer is made from one of LiF and LiO.

7. The device according to claim 3, wherein said electroluminescent layer (28b) is made from an inorganic material.

8. The device according to claim 3, wherein said electroluminescent layer is made from an inorganic material and said device further comprises at least one dielectric layer(27b).

9. The device according to claim 1 wherein said semi-absorbing material has a "k" value of less than about 0.2 and greater than 0.1, an "n" value of from about 1.3 to about 3.5, and a thickness optimized to reduce optical interference at a wavelength of visible light of about λ=555nm.

10. A contrast enhancement apparatus (32,36; 32a,36a; 32b,36b) comprising:

a reflective rear layer (36, 36a 36b);

said contrast enhancement apparatus being **c h a r a c t e r i z e d by** further comprising:

an optical interference member (32, 32a, 32b) composed of a single layer of a semi-absorbing material, said optical interference member being in interfacial contact with said reflective layer, said optical interference member for reducing the reflectance of said ambient light towards a viewer facing said optical interference member.

11. The apparatus according to claim 10, wherein said semi-absorbing material is a metal rich oxide chosen from the group consisting of AlO, SiO, InO, and ZnO; or is

a metal:metal oxide chosen from the group consisting of Cr:SiO, Al:SiO, In:SnO, and Al:ZnO.; or is

a metal:metal halide chosen from the group consisting of Al:LiF, Ag:MgF, and AgLiF; or is

a metal:organic thin-film material chosen from the group consisting of Al:Alq_3, Cr:Alq_3, Mg:Alq_3, and Li:Alq_3.

12. An electroluminescent device (20, 20a, 20b) for displaying an image to a viewer (40) in front of said device, comprising:

an anode layer;

a cathode layer;

said electroluminescent device being **c h a r a c t e r i z e d** in that:

at least one of said anode layer and said cathode layer is a front layer (24), and is substantially transparent to electroluminescent light;

said electroluminescent device further comprising:

an electroluminescent layer (28, 28a, 28b) disposed between said cathode layer and said anode layer, said electroluminescent layer having a highest occupied molecular orbital associated with an anode side, and a lowest unoccupied molecular orbital associated with a cathode side; and

an optical interference member (32, 32a, 32b) for reducing the reflectance of ambient light towards said viewer, said member disposed between said anode layer and said cathode layer, said optical interference member having a work function such that a first difference between said work function and a first energy level that is required to remove an electron from said highest occupied molecular orbital, when said optical interference member is at said anode side, approaches zero; and such that a second difference between said work function and a second energy level that is required to remove an electron from said lowest unoccupied molecular orbital, when said optical interference member is at said cathode side, approaches zero;

said optical interference member being composed of a single layer of a semi-absorbing material.

13. A method of displaying an image to a viewer (40), **characterized by** the steps of:

emitting light from a light emitting means (28, 28a, 28b) sandwiched between a substantially transparent front electrode (24, 24a, 24b) and a reflective rear electrode (36, 36a, 36b) ; and

reducing spectral reflectance from ambient light incident upon the light emitting means with an optical interference member (32, 32a, 32b) disposed in interfacial contact with the rear electrode, the optical interference member being composed from a single layer of a semi-absorbing material.

14. A method of reducing reflected ambient light towards a viewer (40), **characterized by** the steps of:

reflecting a first portion (R1) of ambient light (L_{amb}) incident upon a semi-absorbing material (32, 32a, 32b);

absorbing a second portion ($L_{amb}1$) of the ambient light as it passes through the material;

reflecting a third portion (R2) of the ambient light after it passes through the semi-absorbing material and when the third portion is incident upon a reflecting material (36, 36a, 36b) in interfacial contact with the semi-absorbing material;

absorbing a fourth portion of the ambient light from the third portion as the third portion passes back through the semi-absorbing material; and,

transmitting the remainder of the ambient light out of the reflecting portion, the remainder being out of phase with the first portion such that the first portion and the remainder destructively interfere thereby reducing the ambient light reflected back towards the viewer.

Fig. 1

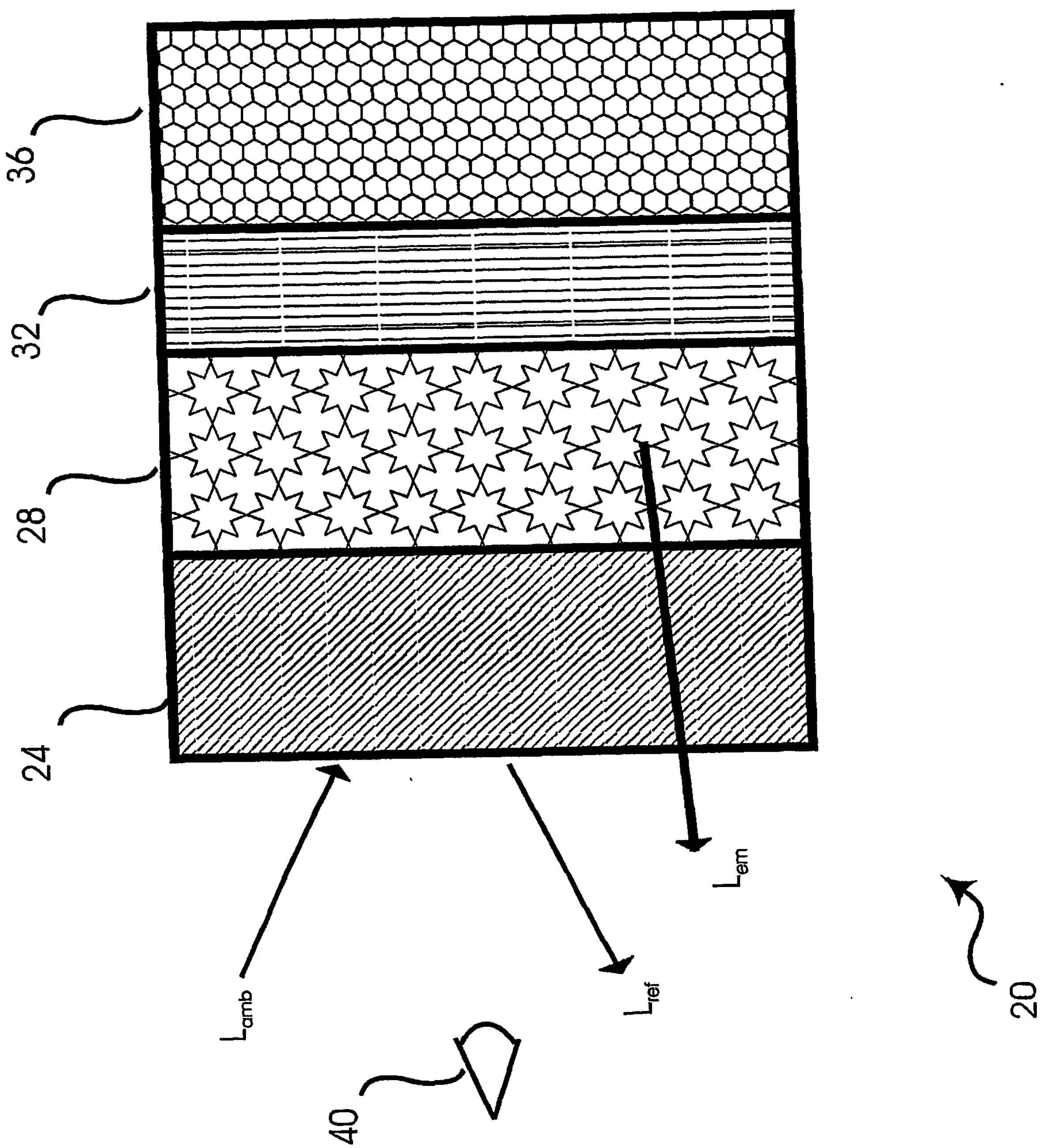
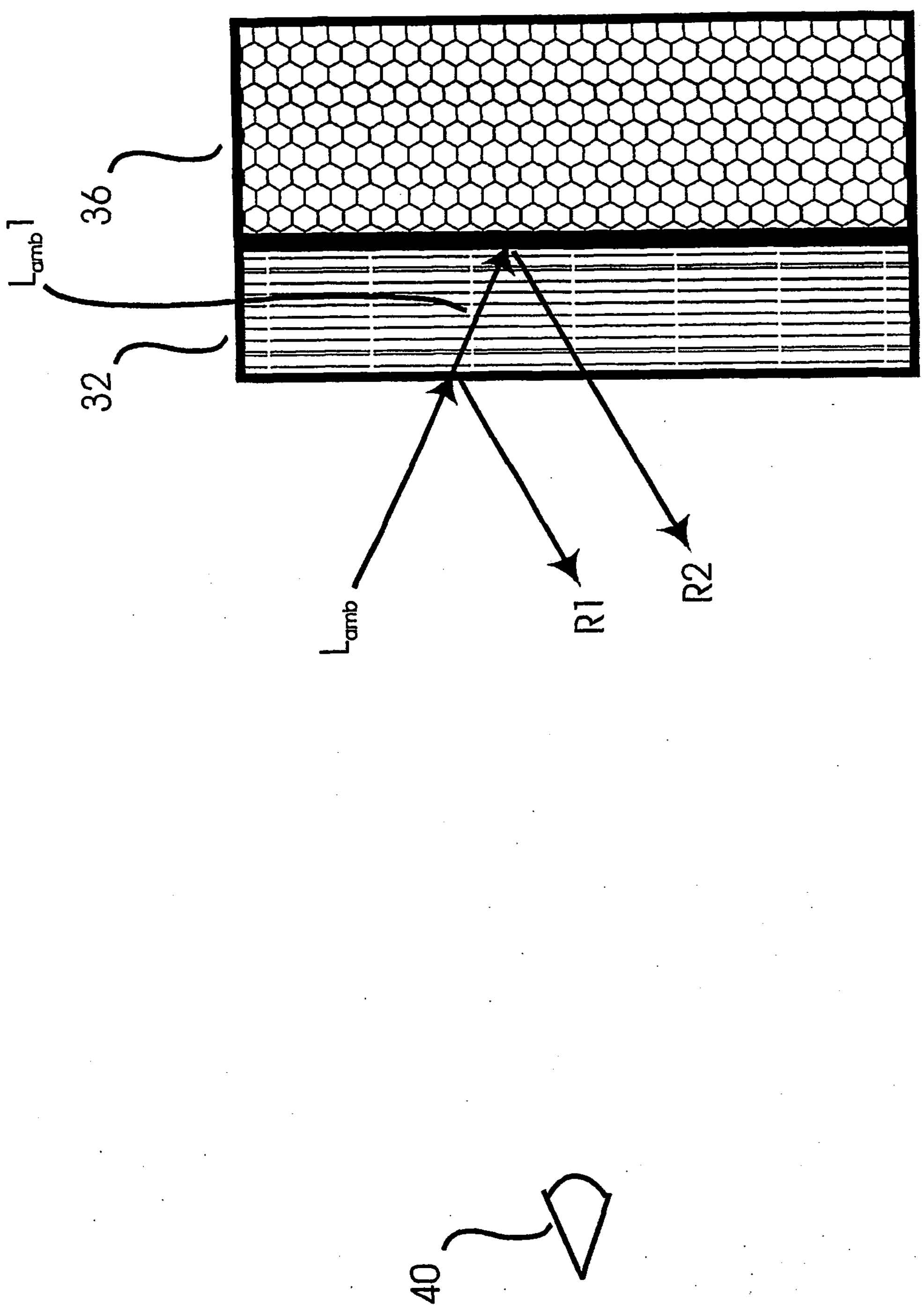


Fig. 2



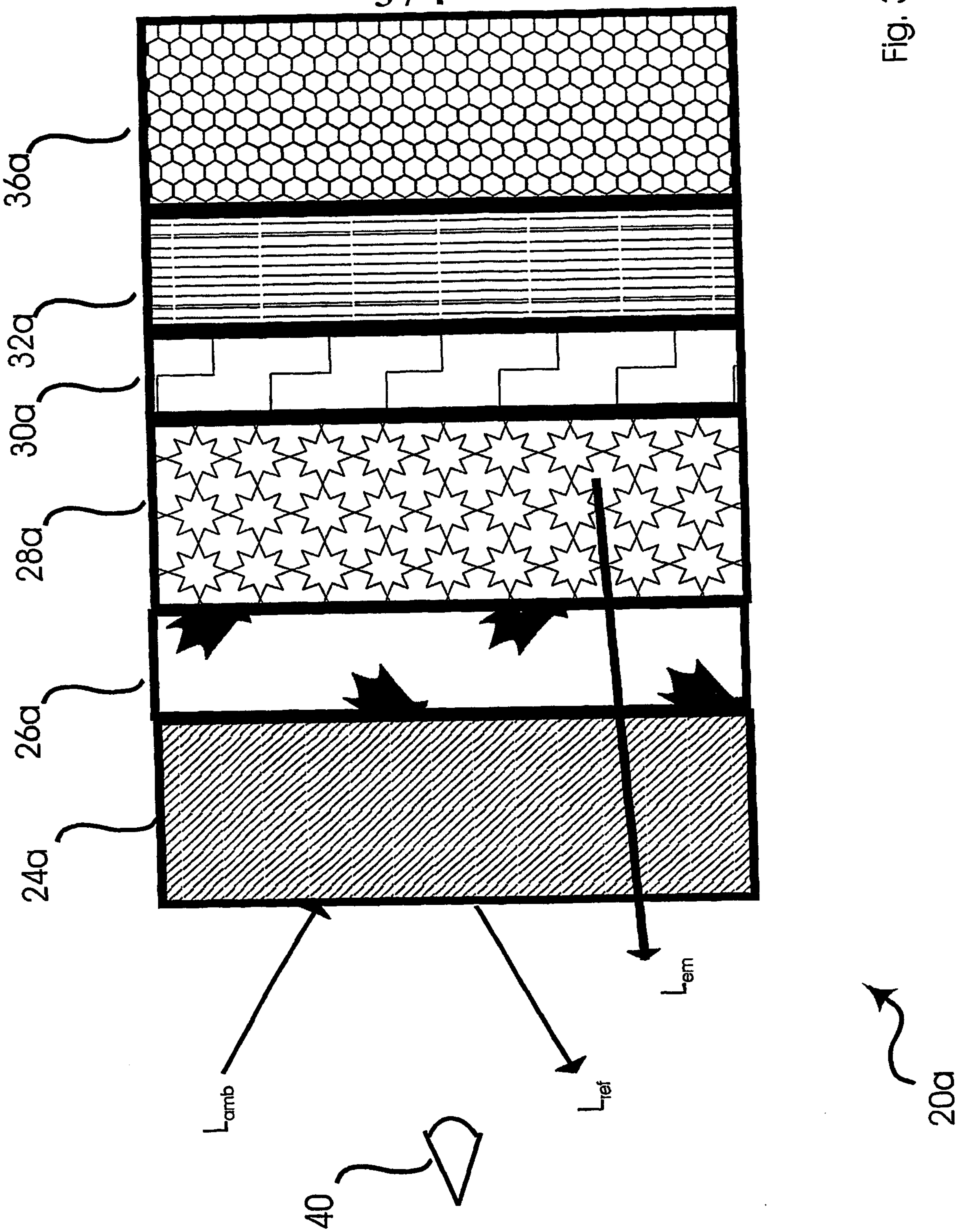
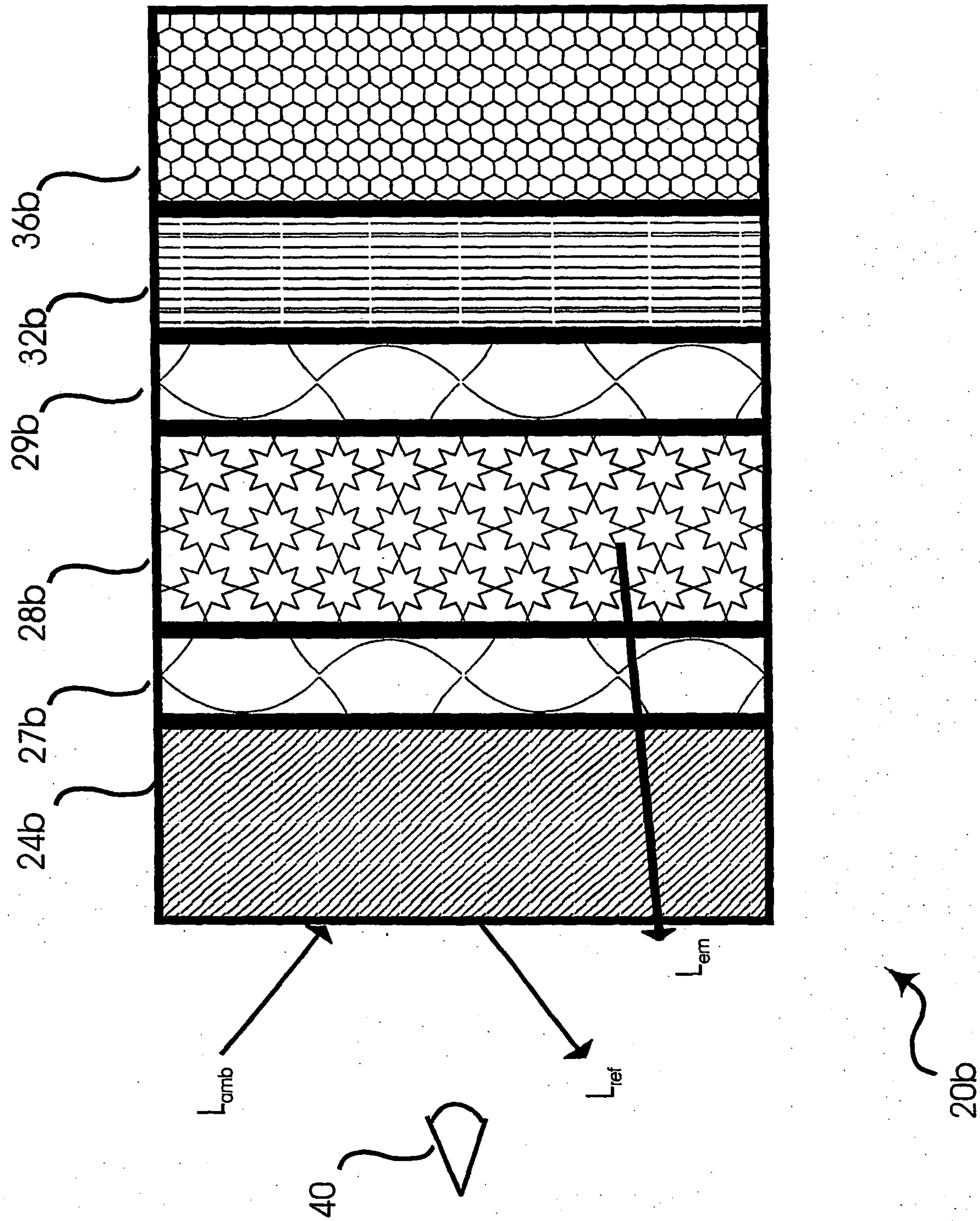


Fig. 3

Fig. 4



INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 02/00844

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B33/22 H05B33/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	EP 0 372 763 A (CANADA NAT RES COUNCIL) 13 June 1990 (1990-06-13) cited in the application page 3, line 24-40 page 4, line 36 page 5, line 37-45 page 5, line 56 -page 6, line 3 page 6, line 6-38 claims 1,3 table 1 ---	1-3,7,8, 10,11,13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
5 September 2002	08/10/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Doslik, N

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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